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High Grading Scallops on the Ocean Bottom

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Project Title : High Grading Scallops on the Ocean Bottom

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Introduction

The Atlantic sea scallop (*Placopecten magellanicus*) resource supports large offshore fisheries on Georges Bank and the Mid-Atlantic bight. Sea scallops are bivalves living on the sea bottom along the continental shelf and are largely harvested by dredges outfitted with bags constructed of steel rings with inside diameter of 4" and designed to select out certain size scallops. Dredges are towed along the sea floor where things in its path that are not deflected (fish/turtle excluders on dredges) or able to swim away (avoid the dredge) are collected in the dredge bag. Dredges are hauled back on-board, bags dumped of their catch, and then put back overboard for the next tow. Depending largely on bottom type (hard, soft, rocky) and tow time/speed, the amount of targeted scallops varies along with the amount of non-targeted catch, as rocks, debris, old/cut shell, starfish/sand dollars, and bycatch (fish, crabs). Once dumped on deck, the catch is "shacked", with crew culling out scallops from the rest of the non-targeted catch. Depending on bottom type, the dredge bags can become loaded with non-targeted bycatch and "trash", resulting in increased labor culling scallops. The marketable part of the bivalve is the adductor muscle (meat) that holds the two shells together. Scallop meats are shucked from the shell at sea, typically during periods between tows, with the shells and viscera thrown overboard. Scallops meats are sold by the count (number per pound) with a higher price paid for the larger meats. The larger the scallop shell, the larger the meat that is shucked from it.

For boats that are limited to the amount of poundage landed per trip ("Day Boats" with 600 lb allowable max), targeting larger scallops can help off-set costs associated with long run times (fuel usage) to get to harvesting areas. For boats out of Hampton Roads, Virginia, runs to the closest scallop resource area (Mid-Atlantic Scallop Rotational Area; Elephant Trunk/ Hudson Canyon) take 24 hours at 9 knots, consuming approximately 500 gallons of diesel and costing $1150 (at $2.30/gallons) . Currently, 30/40 count scallops are $8.00/lb, and the large 10-12 count scallops are $18.00/lb. With limited poundage, profitability in this fishery is greatly dependent on the size make-up of catch.

The current regulation calls for 4" minimal ring size in scallop dredge bags, which selects for 110-115 mm scallops, or around 20-30 count scallop meats (DuPaul 2002). In research findings that established the 4" regulation, differences in catch performance between 3.5" and 4" rings were evaluated. In that work, the 4" ring dredge was more efficient in selecting out larger scallops and leaving smaller scallops on the sea floor, while also reducing the amount trash retained and therefore on-deck labor. The intent of this study was to extend scallop high-grading beyond that mandated by current management for additional economic and resource conservation benefits, while also providing industry harvesting flexibility relative to resource areas and market value. The opportunity to increase efficiency through high-grading when conditions are favorable, provides flexibility within the scallop industry,

especially for “Day Boats” which are restricted to trip poundage limits. It was proposed to build 2 experimental dredge bags using larger ring diameters and evaluate resulting scallop size catch selectivity, as well as differences in the amount of non-targeted catch. The purpose was to see if the use of larger diameter rings would select for larger scallops (high grade) on the bottom during towing while leaving more smaller scallops on the bottom, and reduce the amount of trash (shell, rocks, debri, invertebrates) retained to lessen labor associated with on-deck culling.

Methods

The goal was to evaluate the catch composition of dredges with larger ring diameters than the current regulated ring size of 4” (inside diameter, ID). The project employed a paired tow experimental design with the vessel towing two 13’ dredges at the same time; one off the starboard side and one off the port side. Dredges with either 4.5” rings or 5” (ID) rings were tested against the standard 4” ring dredge during normal commercial tows. The standard 4” rings used were stock rings made for industry wide use. Because 4.5” and 5” rings were not standard sizes (and the chain industry would not re-tool equipment to make these non-standard size rings), they had to be fabricated individually by local metal shops. Experimental rings were fabricated from 7/16“diameter steel rod, the same as standard 4” rings. The resulting average diameter (ID) of rings were; 4” rings 3.979 (SD .022, N=25), 4.5” rings 4.503 (SD .038, N=25), and 5” rings 4.957 (SD .038, N=25). The weight of individual rings were: 4” = 10 oz, 4.5”=11 oz, 5”= 12 oz.

Dredge bag construction was performed by local scallop fishing supply personnel, with 1110 rings used in constructing the 4” bag, 877 rings for the 4.5” bag, and 710 rings in the 5” bag (Table 1). Rings in all bags were secured together with 2 split links per side (Figure 1) and fastened onto dredges with the same amount of dog-chain (Figure 2). With less rings used, less split links were used providing for less overall weight with increasing ring size; the overall weight of the bags decreased with increasing ring size.

Testing was performed onboard the F/V Little Jesse out of Newport News, VA in open designated areas outside the Mid-Atlantic Scallop Rotational Area; Elephant Trunk over different bottom types (soft, rocky, and/or sandy bottom). Tow durations were 30 minutes. Data collection was performed by crew members under the direction of VIMS Marine Advisory Services staff member (Fisher). Catch from each dredge was dumped on deck, separated into scallops retained, trash, and bycatch with amount of each recorded as number of bushels (Figure 2). Scallops were culled into fish baskets (bushels) as crew, with no grading involved, encountered them. In cases where more than a bushel of scallops was caught, a bushel subsample was used for measuring. In cases where less than a bushel of scallops were caught, all (100%) of the scallops were measured. Scallops were measured on VIMS measuring board to the nearest 2 mm. Trash and bycatch were also recorded by volume (bushels), with species of bycatch noted.

Ring Size	# of rings/bag	weight of bag (lbs)
4”	1110	1109
4.5”	877	930
5”	710	798

Table 1. Number of rings used to construct scallop dredge bags for each ring size tested with resulting total weight of each bag (total weight includes split links and sweep chain).

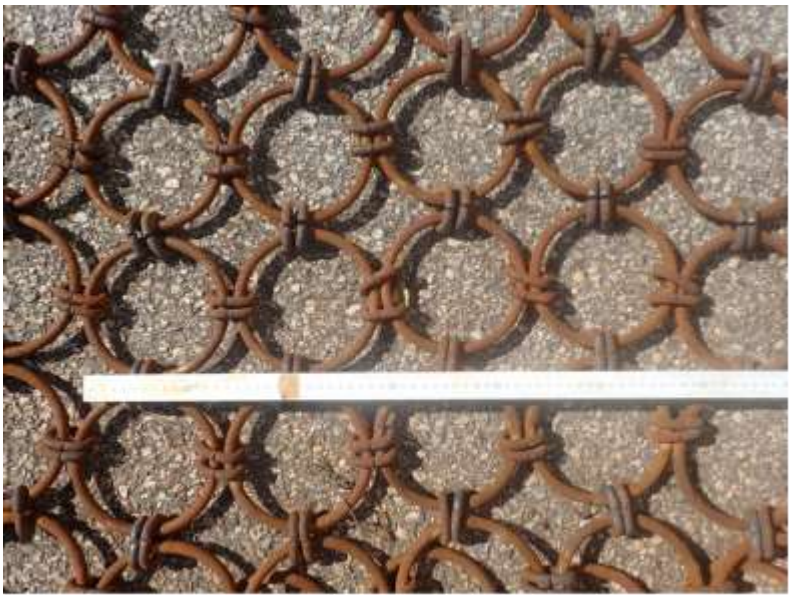

Figure 1. Rings fastened together with 2 split links per side.

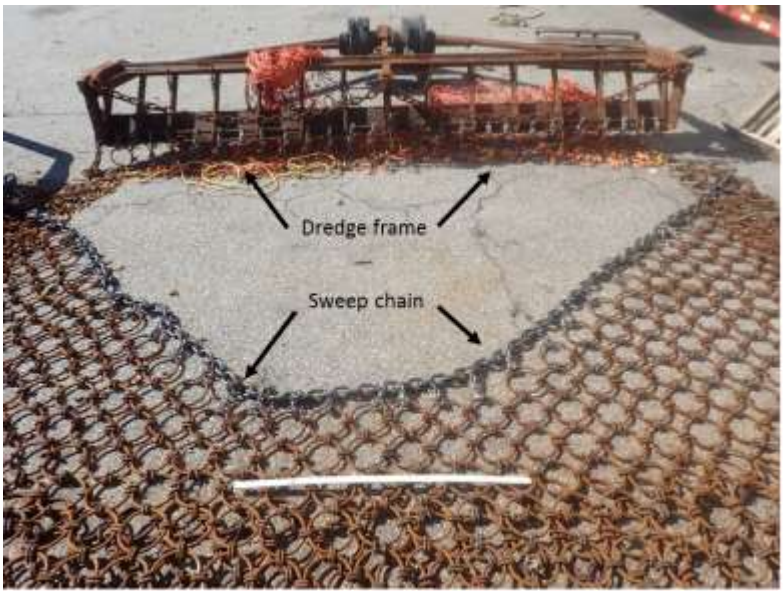

Figure 2, Fabricated scallop dredge bag with 5" rings ready to be fastened onto dredge frame. Sweep chain attached.

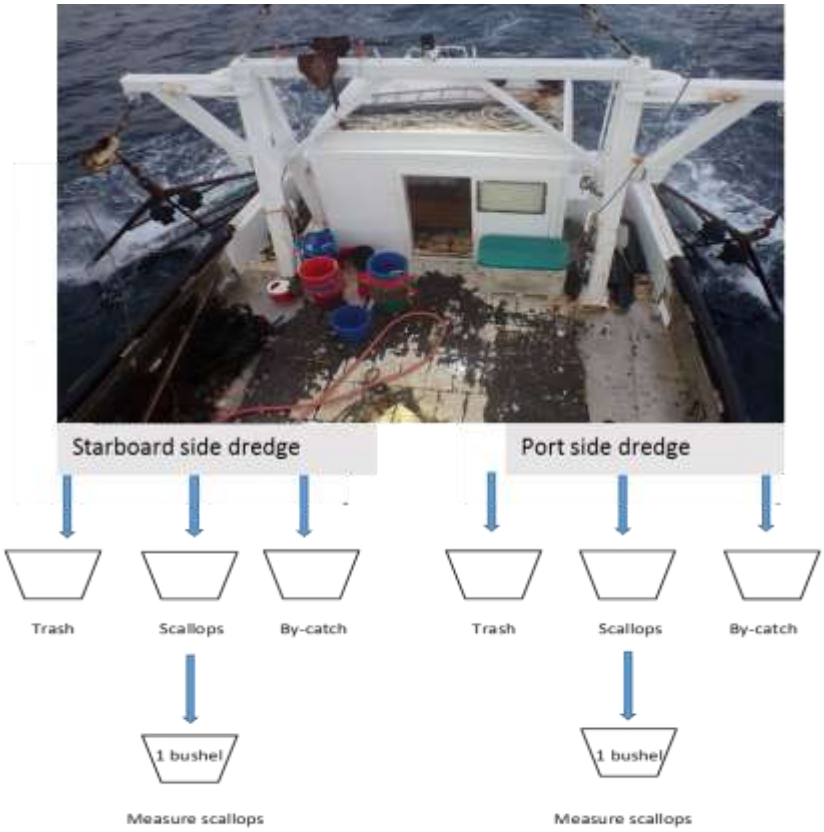

Figure 3. Sampling protocol for side-by-side comparative towing.

Results

Two fishing trips were made into the Mid-Atlantic Scallop Rotational Area; Elephant Trunk, one in April and another in August 2018 to test high grading using larger scallop rings. A total of 40 comparison tows were attempted, but due to fouled tows (dredges not fishing correctly as a result of rough weather), only 36 comparison tows were used for data analysis; 18 comparing 4" to 4.5" rings, and 18 comparing 4" to 5" rings. A total of 6648 scallops were retained for measurement, with the length frequency distribution represented in Figure 4 and the number of scallops per size class (5mm bins) for each ring size presented in Table 2. The larger number of scallops reported for 4" rings is due to: The 4" ring serving as the standard (control) ring size from which the 2 experimental ring sizes were tested against; more smaller scallops fit into a sampling bushel; and because tows with 4.5 and especially 5" rings did not always catch a full bushel per tow.

The 4.5" and 5" rings consistently retained fewer small scallops than the 4" rings, with only a single scallop <110mm retained with the 5" rings. The average size of scallops retained increased with increasing ring diameter (Table 3). With size frequency distributions binned into 5 mm size classes, scallop size selectivity is determined for all ring sizes (Figure 5), with increasing scallop sizes selected out with increasing ring size. The 4" rings selected for 105-115mm scallops, 4.5" rings for 110-120mm scallops, and the 5" rings for 120-130mm scallops. Of note, more large scallops were retained with increasing ring size.

In comparing the number of bushels of scallops (all sizes) retained per tow (Figures 6 and 7), there was a significant decrease in catch with increasing ring diameter over the standard 4" ring size. There was a 45% reduction in catch with the 4.5" rings, and an 81% reduction with the 5" rings. In comparing the amount of trash retained, there was a 68% reduction with 4.5" rings, and an 86% reduction with 5" rings (Figures 8, 9). Trash consisted of shell on hard bottoms, and sand dollars and shell on soft bottoms. In terms of bycatch retained, there was no significant difference (0.5% reduction) with the 4.5" rings, but a significant reduction (70%) with 5" rings. Bycatch consisted of skates (~90%), monkfish (~7%), flounder (~2%), and Jonah Crab (~1%). The first 7 tows comparing 4" v 4.5" rings were inundated with small-medium size skates (ranging from 15 to 82 skates per dredge). This resulted in large number of bycatch, but similar retentions between the 2 ring sizes in those tows.

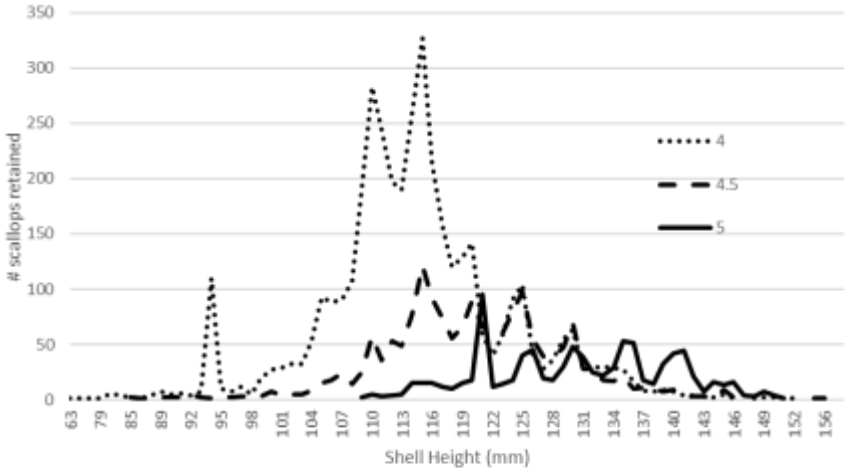

Figure 4. Length frequency of scallops retained for measurement from dredges with 4", 4.5", and 5" diameter (ID) rings.

Shell Ht (mm)	*4"*	*4.5"*	*5"*
65	1	0	0
70	1	0	0
75	1	0	0
80	1	0	0
85	12	3	0
90	17	6	0
95	137	13	1
100	70	18	0
105	238	37	0
110	758	138	7
115	1217	336	42
120	762	377	70
125	352	365	179
130	223	248	160
135	142	111	167
140	48	47	157
145	15	19	101
150	6	4	34
155	2	1	2
160	1	1	0

Table 2. Total catch of sea scallops from comparative tows of experimental dredges with 4.5 and 5 inch rings verse standard dredge with 4" rings.

Ring Size	Ave SH (mm)	N
4"	114.4	4004
4.5"	120	1724
5"	130.3	920

Table 3. Average shell height (mm) of all scallops retained during 18 comparative tows.

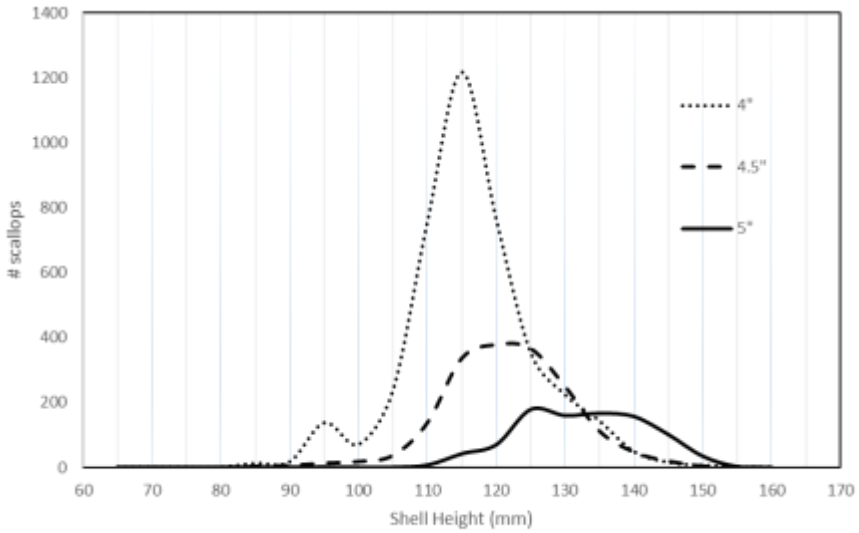

Figure 5. Number and size of sea scallops caught in dredges with 4", 4.5", and 5" rings.

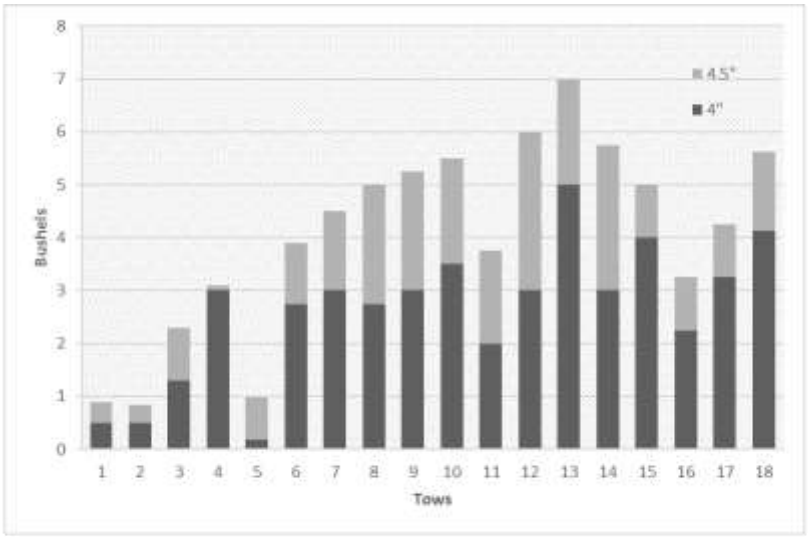

Figure 6. Scallops caught (bushels) by 4.0" and 4.5" ring dredges in comparative tows (N=18).

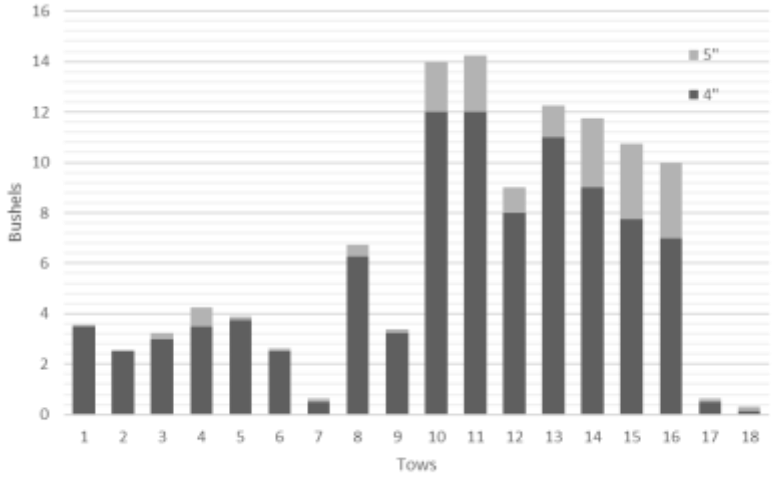

Figure 7. Scallops caught (bushels) by 4" and 5" ring dredges in comparative tows (N=18).

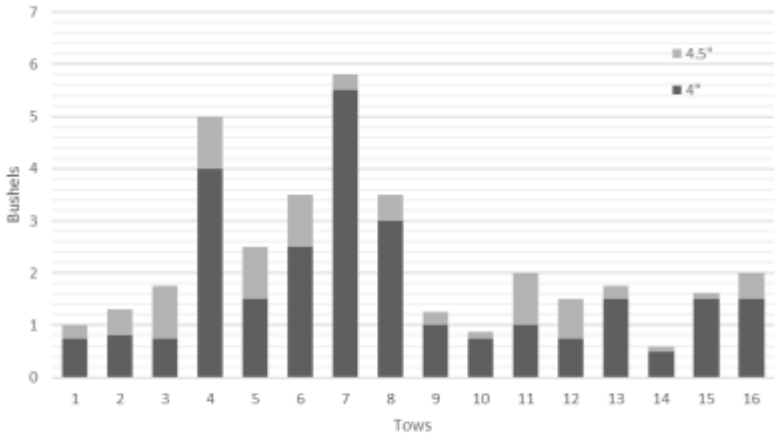

Figure 8. Trash (bushels) retained by 4.0" and 4.5" ring dredges in comparative tows (N=16).

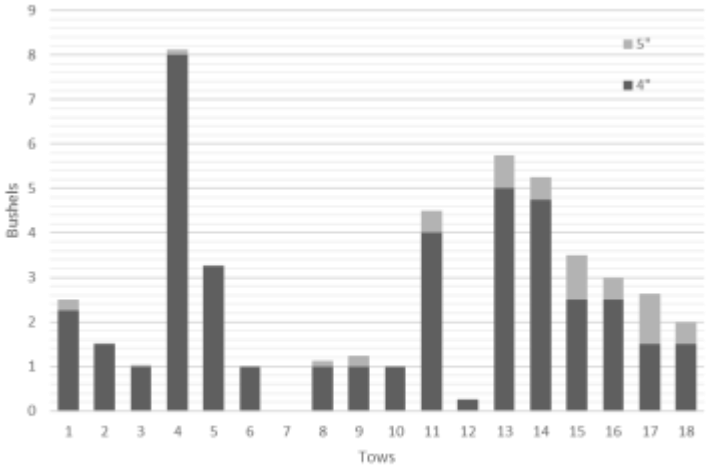

Figure 9. Trash (bushels) retained by 4.0" and 5" ring dredges in comparative tows(N=18).

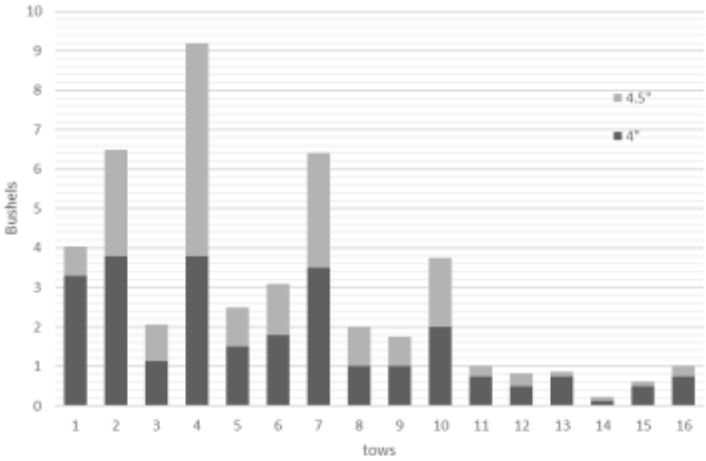

Figure 10. By-catch caught by 4" and 4.5" ring dredges in comparison tows (N=16)

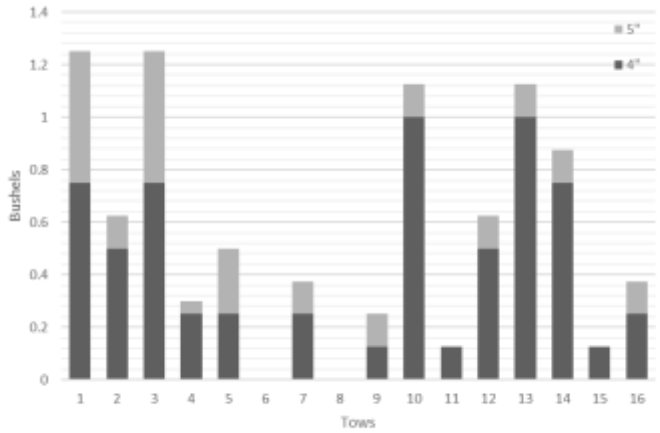

Figure 11. By-catch caught by 4" and 5" ring dredges in comparison tows (N=16).

Discussion

The larger diameter rings used in scallop bags selected for larger scallops compared to the standard 4" ring size. When length frequency data are binned into 5 mm size classes (Figure 5), size selectivity becomes more apparent. Scallop size selectivity of 4" rings in this study were similar to that reported by DuPaul et al., (1999) selecting out 110-115 mm scallops (20-30 meat count), a size targeted by management as a minimal optimal age/size for harvest (to maximize stock yield per recruitment). By increasing the ring diameter beyond 4", escapement of less optimal size scallops (<110mm) is achieved while retaining optimal size scallops (Figure 12). As ring diameter increased, the amount of scallops of minimal optimal size decreased, but the retention of the larger size scallops increased; resulting in an the overall decrease in marketable scallops. There was a significant decrease in total catch with increasing ring diameters over the standard 4" ring size (Figures 6, 7 reflecting all scallop sizes retained), but a large portion of catch with 4" rings were sub-optimal scallops (Figure 12). The overall decrease in harvestable catch with 4.5" rings compared to 4" rings may have some utility when other factors considered (less sub-optimal scallops retained, less trash, less bycatch). However, though the 5" rings provided maximum efficiency in high grading the largest scallops while providing a near 100% reduction in sub-optimal scallops, total catch achieved within the scope of this study would likely not provide a feasible mechanism for high grading. High grading with 5" rings would likely be most effective in areas with high densities of larger scallops, areas not seen within this study.

As noted in this study, the phenomenon of largest scallops not being retained in the smaller 4", and to lesser degree in the 4.5" rings, compared to the 5" rings has been reported in studies comparing 3.5" and 4" rings (Bourne, 1965, DuPaul and Kirkley 1995, DuPaul 2002). The reason(s) for this are not clear, with the possibility of changing hydrodynamics within bags as they fill during towing allowing for scallops with larger surface area to be pushed out. Since tows in this study resulted in small amounts of scallops retained in all ring sizes tested, other causes are likely at work.

The size and number of rings used per testing bag resulted in bags (and therefore dredges) with larger rings weighing less. The resulting effect of dredge weight on dredge performance was not tested within the scope of this work. It was theorized that lighter dredges would consume less fuel during towing, providing for additional fishing efficiency. However, controlling dredge-bottom interaction for dredges

of varying weight by adjusting towing variables (speed, duration, and cable length/scope) to maximize performance of each dredge could not be performed under the employed pair towing study design. Testing these towing variables would need to be performed for each ring size to see how they affect dredge catch efficiency.

The practice of high grading on the bottom for the more valuable scallop size has merit if reduction in overall effort can be combined with resource conservation outcomes. Since dredge performance relative to different ring sizes was not tested, efficiency in scallop capture and fuel usage of the lighter, larger ring dredges can only be theorized. A reduction in labor, in terms of less time shacking/culling and shucking scallops by crew to reach allotted total poundage, is possible. Resource conservation is possible in terms of reduced scallop discard mortality; less physical damage to smaller scallops left on the bottom from reduced dredge interaction, not exposing smaller scallops to environmental stress while passing through thermal cline in water column and on-deck ambient air temperatures, which can be excessively high during summer periods. If selectivity for larger scallops can be demonstrated with those added benefits, the real benefit to the industry would be the flexibility to choose to high-grade whenever the resource and market warrant it. With the larger U10/12 scallop likely to always demand a higher value, even during periods when the scallop size distribution fluctuates within any given resource area, the ability of boats to target larger scallops by high grading should reduce the overall cost to boats while leaving smaller scallops on the bottom to grow. This is especially true for day boats from Hampton Road Virginia ports, which burn a lot of fuel just to get to and back from scallop harvest areas.

A more robust study is needed within resource areas with broad year classes and varied bottom-types to adequately evaluate high grading with larger rings. Targeting areas with large volumes of seed mixed in with older/larger year classes would further evaluate the utility of high grading sea scallops on the bottom using larger dredge bag rings, for both resource conservation and industry economics purposes.

Ring size	scallops <110	Total retained	% retained
4"	953	4004	23.8
4.5"	215	1724	12.4
5	3	920	0.32

Figure 12. Retention of scallops <110 mm for testing ring diameters.

Captain's notes

The catch rate between the 4" and 4.5" rings was noticeably different. The 4.5" ring caught about 1/3 of the 4" bag. The scallops in the 4.5" bag were noticeably larger than the catch of the 4" bag. The catch rate between the 4" and 5" ring was very noticeable as the 5" ring catch rate was significantly less than the 4" ring. The 5" ring bag did however seem to catch larger scallops than the 4" bag. Trash was noticeably reduced as the ring size increased. In areas where there is a large population of sand dollars, and where the scallops are generally healthier, the larger rings may be effective to allow towing in these areas that are too populated with sand dollars. Bycatch was slightly reduced as the ring size increases. I

believe that some of these results would change if this study was conducted in an area very heavy population of scallops or in areas of very heavy population of sand dollars.

In areas where scallop population is healthy with larger meats, the high grading could be effective given the current catch rate of the 4.5" ring dredge. However, the 5" ring catch rate may not be cost effective unless in a very high population of scallops, but that data was not obtained in this study. The crew on a day boat trip may be reduced because of the increased size of the scallops and decreased amount of trash. I am just not sure if the meats from the scallops from the 4.5" and 5" would be large enough in certain areas to become the next size grade of marketed scallops.

Mortality of smaller scallops on the deck would be reduced with high grading. Smaller scallops, and seed scallops, would be left on the bottom using the larger rings. This would be based on the population density of scallops in the areas fished. High grading would need to be tested in these areas of high scallop densities.

The larger the rings are the less the bag weighs. I do not believe that the small differences in weight between the dredge bags would affect the fuel consumption during towing. I do however feel that the difference in weight way effect the way each bag catches. It is unknown as to how changes in tow speed or amount of cable length changing the scope would have on catch, since tow tactics were based on the typical drags of a 4" ring bag. Catch rate seemed to be relative as changes were made, but were always held to the same as the 4". Numerous combinations of tow tactics would need to be performed to check the difference between the bags catch rate at different cable lengths and speeds.

This study was done during trips with bad weather (high winds, large swells). It seemed that as the weather got rougher the catch rate of all sizes increased. Rougher weather does allow the dredge to surge and make the dredge dig harder into the bottom. The amount of trash became less of a difference between the 4" and larger rings as the up and down surging when hauling the dredges back up from the bottom washes trash out of the bag. The reduction in trash was more evident in calm weather than in rough weather.

The consistent lack of larger scallops in the 4” dredge compared to the larger rings was puzzling. It could be possible that the scope and speed that is good for the 4" ring bag may not be optimum for the larger rings. It also may have to do with the larger rings contouring to the bottom differently that the 4" ring.

Many things should be tested and expanded on from this study. Dredge configuration and tow specs would need to be established. The larger rings may not lay on the bottom and move across the bottom the same as the smaller rings. The weight of the larger ring bags is less than the 4" ring bag. Things to consider is that the scope and speed for optimal catch may be different for each ring size. Typical double dredge boats use the two dredges that are built the same to compare and adjust against each other and to find the best results. Drags in multiple different areas should be done to check scallop population density effects on the grading of the scallops. For example, the closed areas that have smaller shells, large meat size, and dense population that are located in heavy populations of sand dollars. Additionally, testing should be done in closed areas where a 4" ring bags are filled to capacity in 20-minute tows or less. If the dredge is to capacity in 20 min or less, the effectiveness of using larger rings to high grade on the bottom would be tested. The size of the meats in different areas and conditions should also be checked to make sure that the targeted high-graded scallops are grading out to the next more valuable size.

Note

F/V Little Jesse was involved in a grounding in Morehead City North Carolina on November 19, 2017. She ran aground in the rocks entering the harbor. The vessel sustained major damage to the hull, wheel, kort nozzle, keel cooler system, rudder and main drive shaft, and was put on the railway for repairs November 27, 2017, which delayed this study.

Literature cited

Bourne, N. 1965. A comparison of catches by 3- and 4-inch rings on offshore scallop drags. J. Fish. Res. Can. 22(2): 313-333.

DuPaul, W.D. and J. E. Kirkley. 1995. Evaluation of sea scallop dredge ring size. Contract report submitted to NOAA, National Marine Fisheries Service. Grant #NA36FD0131.